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Soil Survey—Desert Experimental Range, Utah

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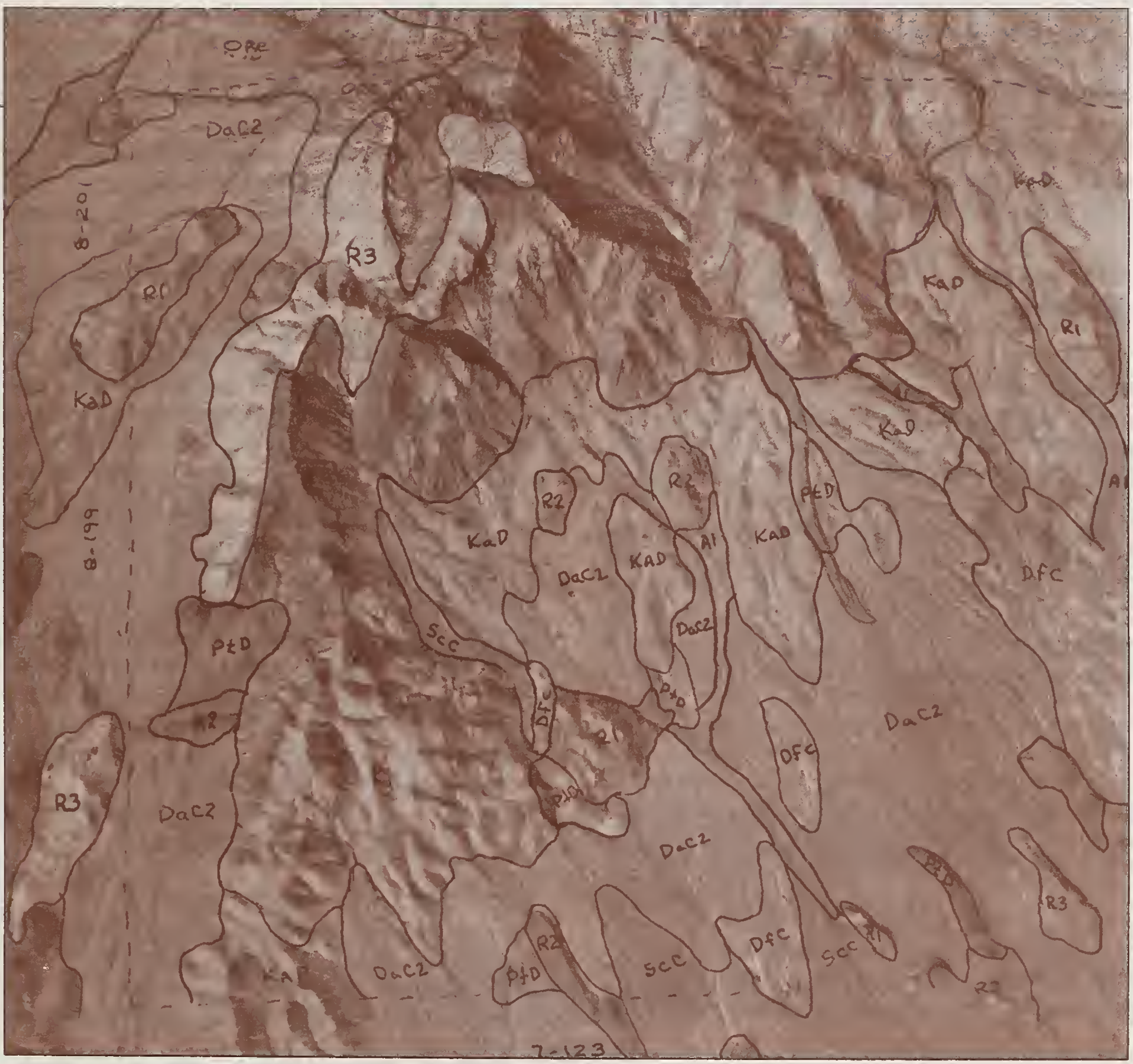

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Cover: Aerial photographs (1:30,000 scale), taken of the Desert Experimental Range in 1970, were used to locate mapping unit boundaries and to estimate total area for each soils series complex.

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Soil Survey—Desert Experimental Range, Utah

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Introduction

The Desert Experimental Range in southwestern Millard County, UT, encompasses 22,533 ha (87 sections) within townships 24 and 25 south, ranges 17 and 18 west (fig. 1). This area is maintained by the Intermountain Research Station, Shrub Sciences Laboratory at Provo, UT. It is used as rangeland for livestock under controlled systems of management.

During the late summer and early fall of 1970, soils were mapped on the entire Desert Experimental Range. Chief objectives were to determine: (1) the kind, extent, and distribution of major soils and groups of soils, (2) the type of vegetation associated with each major soil group, and (3) the correlation between herbage production and soil groups.

Physiographic Setting

The Desert Experimental Range occurs in the Great Basin which is characterized by broad, sparsely vegetated desert valleys with closed drainage systems and intermittent mountain ranges. Elevation ranges from 1,554 m on the Pine Valley hardpan to 2,578 m on the top of Tunnel Springs Mountain, however, most of the area is below 2,000 m. Elevation at Station headquarters is 1,600 m.

Long, broad coalescing alluvial fans start at the base of the mountains and continue to the valley floors. These fans are dissected by a network of gullies. Ephemeral drainage waters flow through the gullies to the large playa northeast of headquarters. An ancient lake occupied the playa and surrounding areas in Pine Valley. Remnants of bars and lake shorelines are present, although many have been partially or completely altered by floodwaters. Buried lake sediments are common.

Geology

The mountains are mostly fault-block uplifts with a general north-south trend. Sedimentary rocks are the dominant feature on the landscape. Sevy dolomite is extensive (Hintze 1980) with Laketown dolomite, Simonson dolomite, Fish Haven dolomite, and Guilmette limestone also present. Tintic quartzite is a light-colored formation commonly associated with the dolomite. Early Tertiary volcanic rocks occurring on the south and east include andesite, trachyte, latite, and rhyolite materials.

Factors of Soil Formation

Five major factors of soil formation are considered as they relate to the Desert Experimental Range.

Climate

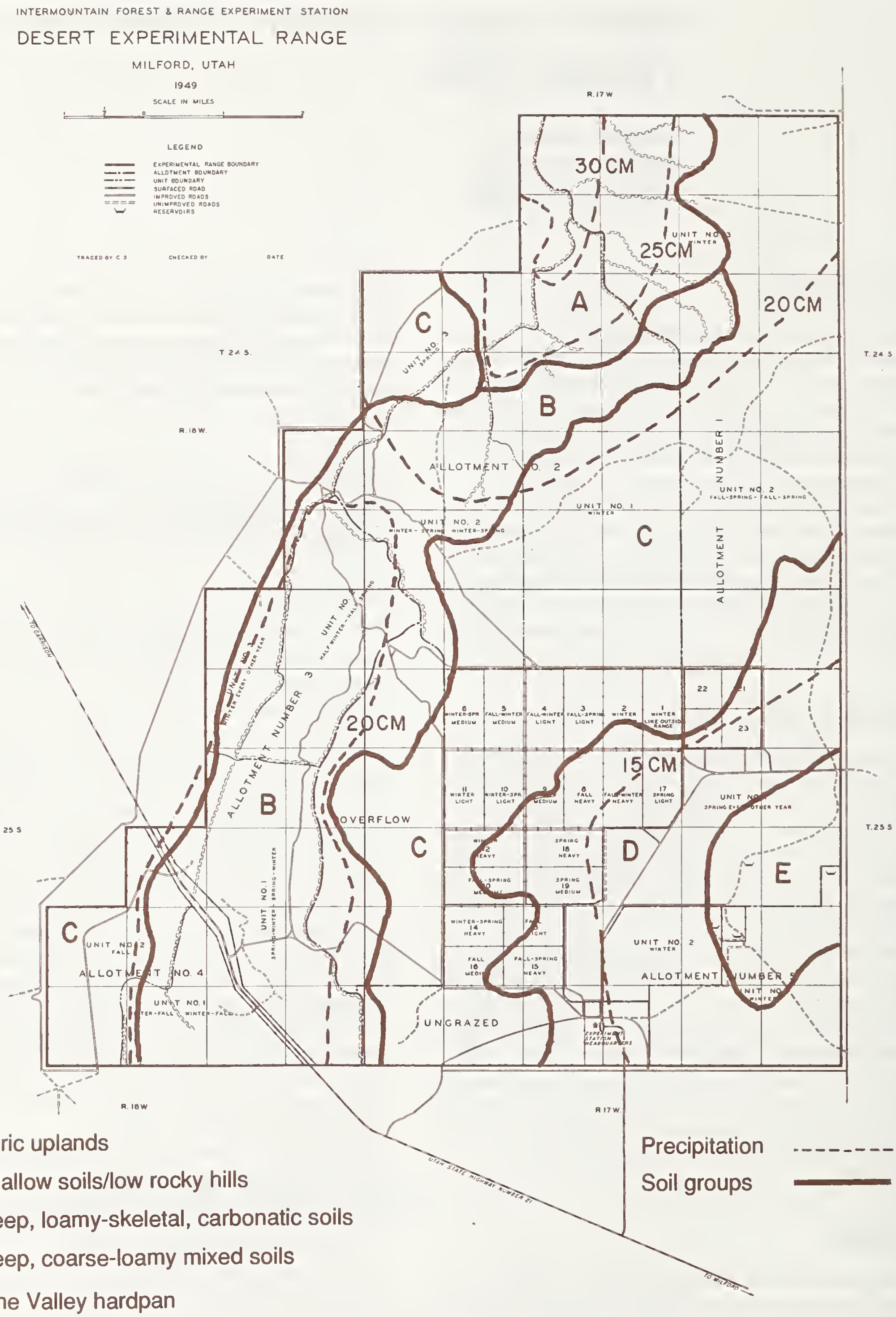
Temperature and precipitation influence the physical and biological processes within the soil. Sparse precipitation limits vegetation production and soil litter accumulation. Also, insufficient moisture is received to move significant amounts of clay and salt through the soil. Therefore, calcification and salinization are the dominate pedogenic processes at work.

Mean precipitation is greatest in July and August (table 1). Infrequent, locally intense storms occur, often with significant runoff, and little moisture reaching the root zone. December, January, and February are the driest months although moisture received in the winter and spring is more effective in recharging the soil than precipitation received during summer.

Ashcroft and others (1992) show mean annual precipitation at Station headquarters is 15.8 cm, but as much as 22 or as little as 9 cm is expected 1 year in 10. Precipitation increases to about 20 cm in the higher basins, reaches 25 cm at the base of the northern mountains, and exceeds 30 cm on higher portions of Tunnel Springs Mountain (fig. 1).

Recorded air temperature extremes are –40 °C and 40 °C, with a mean annual air temperature of 9.45 °C. January has the lowest and July has the highest mean monthly temperature (table 1). The freeze-free period is 120 to 140 days.

Mean annual soil temperature at a depth of 50 cm is 10 to 11 °C. Mean summer soil temperature is 21 to 22 °C. During the fall and winter months, soil temperatures exceed air temperatures. From March



A—Xeric uplands

B—Shallow soils/low rocky hills

C—Deep, loamy-skeletal, carbonatic soils

D—Deep, coarse-loamy mixed soils

E—Pine Valley hardpan

Figure 1—Location map showing soil groups and mean annual precipitation.

Table 1—Air temperature and precipitation patterns at the Desert Experimental Range.

Month	Precipitation[a] Mean	Precipitation[a] Range	Temperature[a] Mean	Temperature[a] Range
	- - - - - *cm* - - - - - -		- - - - - - - *°C*- - - - - - - -	
January	0.76	0 to 3.18	–3.00	–9.6 to 2.9
February	0.71	0 to 2.77	0.50	–7.9 to 4.2
March	1.37	0 to 3.10	3.67	1.2 to 5.2
April	1.47	0 to 4.39	8.00	5.7 to 10.8
May	1.58	0 to 7.42	13.22	10.2 to 15.8
June	0.99	0 to 3.73	18.72	16.1 to 20.9
July	2.06	0 to 7.57	23.17	22.0 to 24.6
August	2.31	0 to 5.26	21.89	20.7 to 23.6
September	1.57	0 to 3.73	16.83	12.9 to 18.6
October	1.32	0 to 9.63	10.11	9.2 to 13.1
November	0.89	0 to 6.71	2.78	–2.3 to 5.6
December	0.74	0 to 3.99	–2.17	–6.2 to 1.2
Mean annual	15.77	7.13 to 28.19	9.45	8.1 to 10.2

[a]Precipitation and temperature records cover 13 years (1935-1947) and 35 years (1950-1984), respectively.

through July, mean soil and mean air temperatures are similar. Soil temperatures exceed 5 °C from the middle of March to the last of November. These values are not applicable on mountain slopes.

From the standpoint of climatic classification, using a modified Köppen approach (Trewartha 1968), low elevation sites are classified in the Temperate Desert climatic type where arid conditions exist. As precipitation increases, the Temperate Steppe/Hot Summers climatic type is evident, where mean monthly temperature for the warmest month exceeds 22 °C and semiarid conditions exist. With increases in elevation and a concomitant reduction in air temperature, the Temperate Steppe/Warm Summers climatic type is applicable. For this type, mean monthly temperature for the warmest month must be less than 22 °C and mean monthly temperatures must be 10 °C or more at least 4 but not more than 6 months of the year. Hence, only a narrow range of climatic conditions influence soil formation at the Desert Experimental Range.

Parent Materials

Soils developing in sediments from dolomite and limestone have high carbonate content. Many are also laden with cobble and gravel-sized rock fragments that decrease in size and quantity as distance from mountains increases.

In areas where igneous or quartzite parent materials are dominant, soils have a high sand content. Although these soils are lower in carbonates than those developing in limestone and dolomite, carbonates are still plentiful.

Topography

Topographic factors may hasten or delay soil formation. On steep, sparsely vegetated slopes, significant erosion is common. Top soil is removed and soil development is impeded. Water and sediments are moved into the valleys. Increased runoff on floodplains may enhance production of vegetation which may in turn alter soil development.

Living Organisms

Vegetation production depends on precipitation, temperature, and soil fertility. On the Desert Experimental Range, moisture is the primary limiting factor. As a result, only small quantities of vegetation and litter are present to protect the soils from erosion. Also, micro-organism activity is inhibited when soil organic matter is low. Therefore, the influence of living organisms in soil development is curtailed in a desert environment.

Rodents may be as important as vegetation in soil modification at the Desert Experimental Range. The landscape has a conspicuous spotted appearance due to 2 to 20 m diameter patches where soil has been modified by digging and mixing. Vegetation on the modified sites is usually dominated by halogeton (*Halogeton glomeratus*), cheatgrass (*Bromus tectorum)*, Russian thistle (*Salsola iberica*), or winter fat (*Ceratoides lanata*).

Time

Soil development is related to age of the geomorphic surface. Soils with little horizon development occur on the recent alluvial deposits in the valley bottoms and at the mouths of drainage areas. Also, wind erosion is continuing to form small dunes. Older soils with distinct horizons of carbonate accumulation occur on the mountain slopes and on stabilized alluvial fans.

Soil Taxonomy

Taxonomic placement of soils complies with guidelines provided by the Soil Conservation Service (1994). For a more general review of soil taxonomic terms see Donahue and others (1983). An explanation of commonly used soil terminology follows. The reader is further directed to study tables 2 and 3 and figure 2 while reading this publication.

Diagnostic Horizons

There are five diagnostic horizons that are relevant in soil classification at the Desert Experimental Range.

Table 2—Desert Experimental Range soil classification.

Series name	Symbols	Great group	Subgroup	Family
Ansping	AaC	Calcixeroll	Aridic	Loamy-skeletal, carbonatic, frigid
Aysees	AbB	Haplocalcid	Typic	Sandy-skeletal, mixed, mesic
Dera	DaB DaC2	Haplocalcid	Typic	Loamy-skeletal carbonatic, mesic
Hiko Springs	HbB	Haplocalcid	Typic	Coarse-loamy, mixed, mesic
Juva	JbB	Torrifluvent	Typic	Coarse-loamy, mixed, calcareous, mesic
Lynndyl	LdB	Haplocalcid	Typic	Sandy, mixed, mesic
Overland	OrE	Haplocalcid	Xeric	Loamy-skeletal, carbonatic, frigid
Penoyer	PeA	Torriorthent	Typic	Coarse-silty, mixed, calcareous, mesic
Pintwater	PtD	Torriorthent	Lithic	Loamy-skeletal, mixed, calcareous, mesic
Sagers	SaA	Torriorthent	Typic	Fine-silty, mixed, calcareous, mesic
Sardo	ScC	Haplocambid	Typic	Loamy-skeletal, carbonatic, mesic
Tipperary	TcA	Torripsamment	Typic	Mixed, mesic
Uffens	UaB	Natrargid	Typic	Fine-loamy, mixed, mesic
Yaki	YaD	Haplocalcid	Lithic	Loamy-skeletal, carbonatic, mesic

Table 3—Mapping unit names and symbols for Desert Experimental Range soils.

Symbol	Field name	Area mapped
		Ha
A1	Alluvial land	292
AaC	Ansping gravelly loam	79
AbB	Aysees gravelly sandy loam	228
DaB	Dera gravelly sandy loam	705
DaC2	Dera gravelly sandy loam, eroded	6,019
DfC	Dera-Rock outcrop complex	173
HbB	Hiko Springs gravelly sandy loam	625
HcA	Hiko Springs—Juva complex	207
JbB	Juva sandy loam	1,221
JeA	Juva—Playa complex	130
LdB	Lynndyl sandy loam	463
OrE	Overland gravelly loam	722
PeA	Penoyer very fine sandy loam	294
PtD	Pintwater gravelly sandy loam	433
P1	Playa	520
R1	Rockland—Dolomite	2,729
R2	Rockland—Volcanic	450
R3	Rockland—Quartzite	382
SaA	Sagers silt loam	162
ScC	Sardo gravelly sandy loam	2,826
TcA	Tipperary loamy sand	1,353
UaB	Uffens sandy loam	462
YaD	Yaki gravelly loam	2,058
Total		22,533

The most common surface horizon is the ochric epipedon. This is a horizon too light in color, too low in organic matter, or too thin to be a mollic epipedon.

The mollic epipedon is a dark colored surface horizon with at least one percent organic matter and is generally more than 18 cm thick. Structure is strong enough to avoid being hard and massive when dry. Base saturation is 50 percent or more.

A common subsurface feature is the calcic horizon associated with secondary carbonate enrichment. It must be at least 15 cm thick, have at least 15 percent calcium carbonate equivalent, and have at least 5 percent more carbonate than the underlying horizon.

Cambic horizons occupy the position of a B horizon and are so designated. Materials have been altered or removed, but not accumulated. Textures are finer than loamy fine sand. The base of the cambic must extend to at least 25 cm below the surface.

Natric horizons occupy the position of a B horizon and usually have prisms or columns. There is over 15 percent saturation with exchangeable sodium.

Other Classification Criteria

Presently, 11 orders are recognized in soil taxonomy. Only three, Aridisols, Entisols, and Mollisols are found at the Desert Experimental Range. Entisols are soils without genetic horizons or have only the beginning of such horizons. Aridisols at the Desert Experimental Range have an ochric epipedon and either a calcic, natric, or a cambic horizon. Some have both calcic and cambic horizons present. The mollisols have a mollic epipedon.

Each order is subdivided into suborders, great groups, subgroups, families, and series (table 2).

Figure 2—Soil survey map of the Desert Experimental Range, February 1995. Explanations of symbols are found in tables 1 and 2.

To classify soils at the subgroup and family levels, information is needed on soil moisture and soil temperature regimes, soil mineralogy, and particle size groupings. Four modifiers, Aridic, Lithic, Typic, and Xeric are considered. Lithic soils are less than 50 cm deep. The other modifiers refer in part to a particular moisture regime.

To define moisture regimes, a moisture control section is used. The upper boundary is the depth to which 2.5 cm of water will moisten dry soil within 24 hours. Its lower boundary is the depth to which 7.5 cm of water will penetrate dry soil within 48 hours. At the Desert Experimental Range, this usually places the moisture control section between 25 and 75 cm, except on lithic soils where only material above bedrock is considered.

The moisture control section is considered dry if moisture tensions exceed 1,500 kPa (15 bars) and moist if tensions are less than 1,500 kPa. Soils listed in the Typic subgroup are dry more than three-quarters of the time (cumulative) in all parts of the moisture control section when the soil temperature at a depth of 50 cm exceeds 5 °C. Overland soils in the Xeric subgroup and Ansping soils in the Aridic subgroup are dry more than half of the time (cumulative) when soil temperature exceeds 5 °C.

Family criteria needing clarification include soil temperature, mineralogy, and particle size groupings. Soils at the Desert Experimental Range are classified in the mesic temperature regime (mean annual soil temperature at 50 cm depth is 8 to 15 °C) or in the frigid regime where mean annual soil temperatures are less than 8 °C and mean summer soil temperatures exceed 15 °C.

The mineralogy and particle size groupings apply to the "control section." This control section should not be confused with the soil moisture control section. For the soils listed, this control section is between 25 and 100 cm, except for shallow soils where all material above bedrock is considered.

Two mineralogic groups are given: mixed and carbonatic. Carbonatic implies that carbonate content plus gypsum in the control section exceeds 40 percent by weight when all soil material less than 2 mm or less than 20 mm diameter (whichever has the higher percentage of carbonates plus gypsum) is considered. Mixed mineralogy applies when soils have a combination of minerals with no dominant class.

Soils listed as skeletal have more than 35 percent rock fragments by volume in the control section. Fragmental soils have large quantities of rock fragments and insufficient fine earth material to fill the rock fragment interstices. Fragmental soils at the Desert Experimental Range are limited to small inclusions found on steep topography. All other soils have less than 35 percent rock fragments. Textural terms such as sandy and loamy are self explanatory.

Methods

Procedures followed in completing the soil survey and obtaining herbage production estimates are described as follows.

Soil Survey

Soil profiles were examined in hand-dug pits throughout the Desert Experimental Range. As the pits were dug, information was obtained on soil texture, rock fragment content (by volume), reaction, structure, consistence, color, depth, roots, parent material type, pores, physiography, relief, elevation, slope, aspect, erosion, and vegetation as a basis for soils descriptions. Using this information, soils were classified and identified on a working legend. New soils with their identifying symbols were added to the legend as the survey progressed. Miscellaneous land types and complexes were also given symbols and mapped. Most mapping units had one major soil type with inclusions of less extensive soils. Area occupied by inclusions was estimated and is indicated in the descriptions.

Aerial photos (scale: 3.11 cm/km) were used to locate the mapping units. Lines were placed on the photos to delineate soil boundaries. Area of coverage for each soil series was estimated from mapping units (table 3).

Soil pits for modal profiles were opened with a backhoe, except for shallow soils on the mountains where pits were dug with a shovel. Samples were collected and sent to Utah State University for analysis. Emphasis was placed on analyses that were relevant from the standpoint of classification such as texture, carbonate content, cation exchange capacity, exchangeable sodium percentages, electrical conductivity of the saturation extract (EC), percent organic carbon, and moisture holding properties.

Herbage Production

Annual herbage production estimates were obtained from records kept by the Intermountain Research Station, Shrub Sciences Laboratory. Herbage production estimates were correlated with soil groups to detect differences attributable to unique soil properties. Similar soils were grouped for these analyses.

Herbage production estimates were obtained in October from 20 fenced pastures 97 to 130 ha in size. Production measurements for 1938 through 1945, 1947, and 1957 were used. Grazing treatments were imposed on the pastures starting in 1934-1935 with sheep use controlled at light, moderate, or heavy

levels, corresponding to an average of 25, 35, and 42 sheep days/ha (Hutchings and Stewart 1953). Actual grazing intensity for a single year was adjusted according to available forage. Grazing season also varied by pasture with fall, winter, and spring treatments.

Herbage production estimates were based on samples clipped and air-dried and by ocular estimates using 18.58 m^2 circular plots. There were 64 and 48 plots measured for the large and small pastures, respectively.

Some information was previously published by Hutchings and Stewart (1953). Their equation (converted to metric units) for herbage production was used for prediction purposes on soils groups not represented in the pastures. The estimating equation took the form:

$$\text{Herbage production (kg/ha)} = -103.61 + 20.52\ (\text{precipitation}) \quad (1)$$

Where precipitation (cm) is based on moisture received during the 12 months prior to sampling. This equation provides estimates within plus or minus 79 kg/ha (one standard deviation).

The production equation was modified for predictions on shallow and moderately deep soils based on production ratios developed using data provided by Passey and others (1982). It was found that shallow soils produced about 70 percent as much herbage as deep soils and that moderately deep soils produced about 85 percent as much material as deep soils, recognizing that the value for moderately deep could vary from 75 to 100 percent depending on actual soil depths (50 to 100 cm). Using these concepts to modify the above equation gives for shallow soils:

$$\text{Herbage production (kg/ha)} = -72.53 + 14.36\ (\text{precipitation}) \quad (2)$$

and for moderately deep soils:

$$\text{Herbage production (kg/ha)} = -88.07 + 17.44\ (\text{precipitation})$$

These equations provide estimates for most conditions at the Desert Experimental Range.

One other equation was prepared using plant cover measurements taken from 1938 through 1945 and 1947 in the 20 pastures. The following relationships were developed:

$$\text{Herbage production (kg/ha)} = -51.5 + 90\ (\text{plant cover}) \quad (3)$$

Where plant cover measurements were obtained using the square-foot-density method provided by Stewart and Hutchings (1936). With this equation, herbage production estimates can be obtained from plant cover data.

To facilitate use of these equations, an annual precipitation map (fig. 1) was constructed using elevation lines on a topographic map together with precipitation values given by Jeppson and others (1968) and by Ashcroft and others (1992). The precipitation values were correlated with production estimates for each soil group using the above equations.

Production data were grouped to reflect the general soil/landscape patterns found in the 20 pastures. Soils in pastures one through six are deep and composed of primarily loamy-skeletal, carbonatic materials. This implies that soil textures are loamy, rock fragments represent over 35 percent of the soil by volume, and calcium carbonate equivalent exceeds 40 percent by weight. Both the fine materials and the rock fragments are high in carbonate. Production data from these pastures were treated together.

Data from pastures 15, 17, 18, 19, and 20 were also treated together. Soils of these pastures are primarily classified as deep, coarse-loamy where there is less than 18 percent clay in the soil and over 15 percent sand. These soils usually have less than 30 percent rock fragments by volume and less than 40 percent calcium carbonate equivalent.

In both of these soil groups, there is a mesic soil temperature regime where mean annual soil temperature exceeds 8 °C at a soil depth of 50 cm. These soils have an aridic/torric soil moisture regime where soils are dry over three-fourths of the time when soil temperatures exceed 5 °C at a depth of 50 cm.

Information on the remaining nine pastures (7 to 14 and 16) was analyzed using the same approach as on the other pastures, but recognizing that there was a mix of loamy-skeletal and coarse-loamy soils.

For each soil, plant species are identified by common and scientific names (first mention only) using nomenclature found in Goodrich (1986).

Description of Soils and Mapping Units

Table 3 shows the mapping unit names and symbols with the hectares mapped. Miscellaneous land types and complexes are listed and described in alphabetical order along with the soils.

Alluvial Land (A1)

Alluvial lands occur along the larger drainage ways and in small channels that dissect the alluvial fans. Material consists of sand, gravel, cobble, and stones that have accumulated during periods of intermittent flooding. The slopes are generally 1 to 4 percent. Elevation ranges from 1,585 to 1,950 m with mean precipitation varying from 15 to 23 cm.

Vegetation is extremely variable, but desert almond (*Prunus fasciculata*) is usually present with lesser amounts of Nevada ephedra (*Ephedra nevadensis*),

sand dropseed (*Sporobolus cryptandrus*), blue grama (*Bouteloua gracilis*), and cliffrose (*Cowania mexicana*).

Ansping Gravelly Loam (AaC)

The Ansping series consists of very deep, well drained soils with moderate permeability and medium surface runoff. These soils occur on alluvial fans and on short colluvial slopes. Soils are developing in mixed alluvium and colluvium from dolomite and quartzite materials. Elevations range from 2,195 to 2,317 m with slope gradients ranging from 5 to 30 percent. Mean precipitation varies from 28 to 30 cm.

Dominant plants are singleleaf pinyon (*Pinus monophylla*), Utah juniper (*Juniperus osteosperma*), black sagebrush (*Artemisia nova*), bluebunch wheatgrass (*Agropyron spicatum*), bullgrass (*Elymus ambiguus*), Nevada ephedra, broom snakeweed (*Gutierrezia sarothrae*), and galleta (*Hilaria jamesii*). The effective rooting depth is 50 to 100 cm.

Ansping soils are commonly associated with Overland, Dera, and Yaki soils.

Taxonomic Class—Loamy-skeletal, carbonatic, frigid Aridic Calcixerolls.

Typical Pedon—A representative profile of Ansping gravelly loam, 5 to 30 percent slopes, described at a point 183 m south and 427 m east of the northwest corner of sec. 9, T. 24S., R. 17W. follows:

A—0 to 18 cm; brown (10YR 5/3) gravelly loam, dark brown (10YR 3/3) moist; weak thin platy structure; soft, friable, slightly sticky, slightly plastic; few fine, medium, and coarse roots; many fine pores; 25 percent gravel; slightly effervescent; moderately alkaline (pH 8.0); gradual wavy boundary.

Bw—18 to 30 cm; pale brown (10YR 6/3) gravelly sandy loam, dark brown (10YR 4/3) moist; weak fine subangular blocky structure; soft, friable, slightly sticky, slightly plastic; few fine, medium, and coarse roots; 25 percent gravel; strongly effervescent; strongly alkaline (pH 8.6); clear wavy boundary (0 to 15 cm thick).

Ck—30 to 50 cm; light gray (10YR 7/2) gravelly sandy loam, brown (10YR 5/3) moist; massive; soft, very friable, nonsticky, nonplastic; 45 percent gravel; strongly effervescent; strongly alkaline (pH 8.8); clear wavy boundary (15 to 25 cm thick).

C1—50 to 75 cm; pale brown (10YR 6/3) very gravelly sandy loam, brown (10YR 5/3) moist; massive; soft, very friable, nonsticky, nonplastic; 60 percent gravel; strongly effervescent; moderately alkaline (pH 8.4); diffuse wavy boundary (18 to 45 cm thick).

C2—75 to 110 cm; pale brown (10YR 6/3) very gravelly sandy loam, brown (10YR 5/3) moist; massive; soft, very friable, slightly sticky, slightly plastic; 60 percent gravel; strongly effervescent; strongly alkaline (pH 8.8); gradual wavy boundary (35 to 100 cm thick).

C3—110 to 150 cm; pale brown (10YR 6/3) very gravelly sandy loam, brown (10YR 5/3) moist; massive; soft, very friable, nonsticky, nonplastic; 60 percent gravel; strongly effervescent; strongly alkaline (pH 8.8).

Rock fragments average more than 35 percent in the control section. The calcium carbonate equivalent exceeds 40 percent when considering the whole soil less than 20 mm in diameter. Rock fragments have 60 to 65 percent calcium carbonate equivalent with the fine earth materials averaging about 30 percent. Weak cementation with silica that is common for Ansping soils was not observed at the Desert Experimental Range.

Small areas of Overland gravelly loam and alluvial land are included in mapping. These inclusions represent less than 10 percent of the unit.

Aysees Gravelly Sandy Loam (AbB)

The Aysees series consists of very deep, somewhat excessively drained soils with rapid permeability and slow surface runoff. These soils occur on alluvial fans and on old lake shorelines and bars. Soils are developing in mixed alluvium from dolomite, quartzite and igneous materials. Elevations range from 1,585 to 1,675 m with slope gradients ranging from 0 to 10 percent. Precipitation varies from 15 to 18 cm.

Dominant vegetation is shadscale (*Atriplex confertifolia*), galleta, Indian ricegrass (*Oryzopsis hymenoides*), Greenes low rabbitbrush (*Chrysothamnus greenei*), cheatgrass, budsage (*Artemisia spinescens*), winterfat, sand dropseed, and some fourwing saltbush (*Atriplex canescens*). The effective rooting depth is 38 to 63 cm.

Aysees soils are commonly associated with Tipperary, Dera, Juva, and Sardo soils.

Taxonomic Class—Sandy-skeletal, mixed, mesic Typic Haplocalcids.

Typical Pedon—A representative profile of Aysees gravelly sandy loam, 0 to 10 percent slopes, described at a point 396 m north and 396 m east of the southwest corner of sec. 28, T. 25S., R. 17W. follows:

A—0 to 8 cm; light brownish gray (10YR 6/2) gravelly sandy loam, dark grayish brown (10YR 4/2) moist;

moderate medium platy structure; soft, very friable; nonsticky, nonplastic; few fine roots; 25 percent gravel; strongly effervescent; strongly alkaline (pH 8.6); clear smooth boundary (15 to 35 cm thick).

Bw—8 to 33 cm; pale brown (10YR 6/3) gravelly sandy loam, brown (10YR 4/3) moist; weak medium subangular blocky structure; soft, very friable, nonsticky, nonplastic; few fine and medium roots; common medium and fine pores; 20 percent gravel; strongly effervescent; strongly alkaline (pH 8.6); clear smooth boundary (15 to 28 cm thick).

2Ck—33 to 63 cm; very pale brown (10YR 8/3) very gravelly loamy sand, yellowish brown (10YR 5/4) moist; massive; soft, friable, nonsticky, nonplastic; few fine and medium roots; 60 percent gravel; strongly effervescent; strongly alkaline (pH 8.9); clear wavy boundary (38 to 88 cm thick).

2C1—63 to 80 cm; light yellowish brown (10YR 6/4) very gravelly loamy sand, dark yellowish brown (10YR 4/4) moist; single grained; loose; 60 percent gravel; strongly effervescent; moderately alkaline (pH 8.1); gradual smooth boundary (13 to 58 cm thick).

2C2—80 to 150 cm; light yellowish brown (10YR 6/4) very gravelly loamy sand, dark yellowish brown (10YR 4/4) moist; single grained; loose; 60 percent gravel; strongly effervescent; moderately alkaline (pH 8.2).

The upper boundary of the calcic horizon begins at a depth of 20 to 35 cm. The calcic horizon has 15 to 25 percent calcium carbonate equivalent. Rock fragments in individual layers range from 20 to 70 percent, but average more than 35 percent in the control section.

Small areas of Tipperary and Hiko Springs soils are included in mapping. These soils represent 12 to 15 percent of the unit.

Dera Gravelly Sandy Loam (DaB)

Dera gravelly sandy loam is found on long alluvial fans west of headquarters. This unit is similar to the Dera gravelly sandy loam, eroded (below), except few gullies and channels are dissecting the area. Also, many areas have buried calcic horizons and new zones of carbonate accumulation. Winterfat and Indian ricegrass are the dominant vegetation with some shadscale, Greenes low rabbitbrush, budsage, and galleta. Elevation ranges from 1,615 to 1,707 m with slopes ranging from 1 to 6 percent. Mean precipitation varies from 15 to 18 cm.

Hiko Springs gravelly loam and Sardo gravelly sandy loam are included. These soils are scattered throughout the mapping unit and represent about 15 percent of the area.

Dera Gravelly Sandy Loam, Eroded (DaC2)

The Dera series consists of very deep, well drained soils having moderate permeability and medium surface runoff. These soils occur on long alluvial fans dissected by shallow gullies and on short colluvial slopes. Soils are developing in mixed alluvium from dolomite, quartzite, and igneous materials. Elevation ranges from 1,615 to 2,010 m with slope gradients ranging from 3 to 15 percent. Mean precipitation varies from 15 to 23 cm.

Dominant plants are shadscale, Indian ricegrass, and galleta with lesser amounts of blue grama, sand dropseed, budsage, winterfat, squirreltail (*Sitanion hystrix*), fringed sagebrush (*Artemisia frigida*), gooseberry-leaved globemallow (*Sphaeralcea grossulariifolia*), and mountain pepperplant (*Lepidium montanum*). Nevada ephedra occurs when small quantities of igneous alluvium is present. The effective rooting depth is 30 to 70 cm.

Dera soils are commonly associated with Sardo, Aysees, Hiko Springs, Tipperary, and Yaki soils.

Taxonomic Class—Loamy-skeletal, carbonatic, mesic Typic Haplocalcids.

Typical Pedon—A representative profile of Dera gravelly sandy loam, 3 to 15 percent slopes, described at a point 30 m east and 396 m south of the northwest corner of sec. 25, T. 24S., R. 17W. follows:

A—0 to 10 cm; light brownish gray (10YR 6/2) gravelly sandy loam, dark brown (10YR 4/3) moist; moderate medium platy structure; slightly hard, firm, nonsticky, nonplastic; few fine and medium roots; many fine vesicular pores; 20 percent gravel; strongly effervescent; strongly alkaline (pH 8.6); clear wavy boundary (5 to 10 cm thick).

Bw—10 to 33 cm; pale brown (10YR 6/3) gravelly loamy sand, dark brown (10YR 4/3) moist; moderate medium subangular blocky structure; slightly hard, friable, nonsticky, nonplastic; few fine and medium roots; few fine vesicular pores; 20 percent gravel; strongly effervescent; strongly alkaline (pH 8.6); clear wavy boundary (13 to 35 cm thick).

Ck—33 to 55 cm; very pale brown (10YR 7/3) gravelly sandy loam, pale brown (10YR 6/2) moist; massive; soft, friable, nonsticky, nonplastic; 35 percent gravel; strongly effervescent; strongly alkaline (pH 9.0); gradual wavy boundary (23 to 70 cm thick).

C1—55 to 113 cm; pale brown (10YR 6/3) very gravelly sand, brown (10YR 5/3) moist; massive; soft, very friable, nonsticky, nonplastic; 40 percent gravel; strongly effervescent; moderately alkaline (pH 8.4); diffuse wavy boundary (15 to 58 cm thick).

C2—113 to 150 cm; light yellowish brown (10YR 6/4) very gravelly sandy loam, yellowish brown (10YR 5/4) moist; massive; soft, very friable, nonsticky, nonplastic; 50 percent gravel; strongly effervescent; moderately alkaline (pH 8.4).

Rock fragments average more than 35 percent in the control section. The calcium carbonate equivalent exceeds 40 percent when considering the whole soil less than 20 mm in diameter. Rock fragments have 60 to 65 percent calcium carbonate equivalent with the fine earth materials averaging about 30 percent.

Small areas of Sardo gravelly sandy loam, Hiko Springs gravelly sandy loam, and alluvial land are included in mapping. These inclusions represent 10 to 15 percent of the unit.

Dera-Rock Outcrop Complex (DfC)

Dera-Rock outcrop complex occurs on alluvial fans adjacent to the mountains approximately 11 km north of headquarters. The complex includes 70 percent Dera gravelly sandy loam, eroded, 20 percent rhyolite rock outcrop, 5 percent Pintwater gravelly sandy loam, and 5 percent alluvial land with unnamed sandy soils.

The Dera soil occurs on alluvial fans. Rock outcrops are common in the channels where erosion has exposed bedrock. The Pintwater soils are adjacent to the rock outcrops with alluvial lands in the valley bottoms. Dominant vegetation is shadscale, galleta, blue grama, and Greenes low rabbitbrush. Elevation ranges from 1,735 to 1,830 m with mean precipitation ranging from 17 to 20 cm.

Hiko Springs Gravelly Sandy Loam (HbB)

The Hiko Springs series consists of very deep, well drained soils having moderate permeability and slow surface runoff. These soils occur on the lower end of long alluvial fans. Soils are developing in mixed alluvium from dolomite, quartzite, and igneous materials. Elevation ranges from 1,585 to 1,920 m with slope gradients ranging from 1 to 5 percent. Mean precipitation varies from 15 to 20 cm.

Dominant plants are shadscale, galleta, budsage, squirreltail, sand dropseed, Greenes low rabbitbrush, winterfat, Indian ricegrass, and purple three-awn (*Aristida purpurea*). The effective rooting depth is 30 to 63 cm.

Hiko Springs soils are commonly associated with Dera, Sardo, Aysees, Tipperary, and Juva soils.

Taxonomic Class—Coarse-loamy, mixed, mesic Typic Haplocalcids.

Typical Pedon—A representative profile of Hiko Springs gravelly sandy loam, 1 to 5 percent slopes, described at a point 396 m east and 549 m south of the northwest corner of sec. 34, T. 25S., R. 17W. follows:

A—0 to 8 cm; light brownish gray (10YR 6/2) gravelly sandy loam, dark grayish brown (10YR 4/2) moist; weak thick platy structure; soft, friable, nonsticky, nonplastic; few fine roots; many fine vesicular pores; 15 percent gravel; strongly effervescent; strongly alkaline (pH 8.8); clear wavy boundary (8 to 13 cm thick).

Bw—8 to 43 cm; pale brown (10YR 6/3) gravelly loamy sand, dark brown (10YR 4/3) moist; weak fine subangular blocky structure; soft, friable, nonsticky, nonplastic; few fine roots; 20 percent gravel; strongly effervescent; strongly alkaline (pH 8.8); clear wavy boundary (23 to 48 cm thick).

Ck—43 to 90 cm; very pale brown (10YR 7/3) gravelly sandy loam, brown (10YR 5/3) moist; massive; soft, friable, nonsticky, nonplastic; 25 percent gravel; strongly effervescent; strongly alkaline (pH 8.6); gradual irregular boundary (18 to 63 cm thick).

C1—90 to 113 cm; very pale brown (10YR 7/3) gravelly sandy loam, brown (10YR 5/3) moist; massive; soft, very friable, nonsticky, nonplastic; 35 percent gravel; strongly effervescent; strongly alkaline (pH 8.6); clear wavy boundary (15 to 45 cm thick).

C2—113 to 150 cm; brown (10YR 5/3) very gravelly sand, dark brown (10YR 4/3) moist; massive; single grained; loose; 60 percent gravel; slightly effervescent; strongly alkaline (pH 8.6).

Rock fragments average between 25 and 35 percent in the control section. The calcium carbonate equivalent is less than 40 percent when considering the whole soil less than 20 mm diameter. Calcium carbonate equivalent in the fine earth material averages 15 to 25 percent with the calcic horizon averaging near 35 percent.

Small areas of Dera gravelly sandy loam, Sardo gravelly sandy loam, and Juva sandy loam are included in mapping. These inclusions represent 12 to 15 percent of the unit.

Hiko Springs-Juva Complex (HcA)

The Hiko Springs-Juva complex occurs within a 3 km radius of headquarters where ancient lake shorelines and bars commonly cover the long alluvial fans. The complex consists of 40 percent Hiko Springs gravelly sandy loam, 30 percent Juva sandy loam, 20 percent Tipperary loamy sand, and 10 percent Dera gravelly sandy loam. Elevation ranges from 1,554 to 1,585 m where mean precipitation is near 15 cm.

Dominant vegetation includes Greenes low rabbitbrush, winterfat, shadscale, budsage, galleta, and halogeton. The plant communities occur in small patches in a random pattern.

Juva Sandy Loam (JbB)

The Juva series consists of very deep, well drained soils with moderate to rapid permeability and slow surface runoff. These soils occur in valley bottoms and in drainageways. Soils are developing in mixed alluvium from dolomite, quartzite, and igneous materials. Some wind blown sand is also present. Elevations range from 1,554 to 1,829 m with slope gradients ranging from 1 to 5 percent. Precipitation varies from 15 to 20 cm.

Dominant plants are winterfat, halogeton, galleta, and Indian ricegrass with small amounts of shadscale and Greenes low rabbitbrush. The effective rooting depth is 38 to 75 cm.

Juva soils are commonly associated with Hiko Springs, Tipperary, Penoyer, Uffens, and Aysees soils.

Taxonomic Class—Coarse-loamy, mixed, calcareous, mesic Typic Torrifluvents.

Typical Pedon—A representative profile of Juva sandy loam, 1 to 5 percent slopes, described at a point 30 m north and 305 m west of the southeast corner of sec. 22, T. 25S., R. 17W. follows:

A—0 to 10 cm; pale brown (10YR 6/3) sandy loam, dark brown (10YR 4/3) moist; weak thin platy structure; soft, very friable, nonsticky, nonplastic; few fine and medium roots; many medium vesicular pores; 10 percent gravel; slightly effervescent; strongly alkaline (pH 8.6); clear wavy boundary (8 to 10 cm thick).

C1—10 to 43 cm; pale brown (10YR 6/3) sandy loam, dark brown (10YR 4/3) moist; massive; soft, very friable, nonsticky, nonplastic; few fine and medium roots; 15 percent gravel; slightly effervescent; moderately alkaline (pH 8.4); gradual wavy boundary (23 to 40 cm thick).

C2—43 to 78 cm; pale brown (10YR 6/3) sandy loam, dark brown (10YR 4/3) moist; massive; soft, very friable, nonsticky, nonplastic; 10 percent gravel; strongly effervescent; moderately alkaline (pH 8.4); gradual wavy boundary (10 to 65 cm thick).

C3—78 to 108 cm; pale brown (10YR 6/3) sandy loam, dark brown (10YR 4/3) moist; massive; soft, very friable, nonsticky, nonplastic; 10 percent gravel; strongly effervescent; moderately alkaline (pH 8.4); clear smooth boundary (18 to 55 cm thick).

C4—108 to 120 cm; pale brown (10YR 6/3) gravelly sandy loam, dark brown (10YR 4/3) moist; massive; soft, very friable, nonsticky, nonplastic; 25 percent gravel; slightly effervescent; moderately alkaline (pH 8.2); clear wavy boundary (13 to 40 cm thick).

C5—120 to 150 cm; very pale brown (10YR 7/3) sandy loam, brown (10YR 5/3) moist; massive; soft, very friable, nonsticky, nonplastic; 10 percent gravel; slightly effervescent; moderately alkaline (pH 8.0).

Rock fragments average less than 20 percent in the particle size control section. Some profiles have a Ck horizon that does not qualify as a calcic horizon because the calcium carbonate equivalent does not decrease as depth in the profile increases.

Small areas of Tipperary loamy sand, Hiko Springs gravelly sandy loam, and Penoyer very fine sandy loam are included. These inclusions represent 6 to 7 percent of the unit. Alluvial lands account for another 1 to 2 percent.

Juva-Playa Complex (JeA)

The Juva-Playa complex occurs along the southeastern boundary of the Desert Experimental Range at the bottom end of the long alluvial fans. It consists of 75 percent Juva loamy sand, 5 percent Uffens sandy loam, and 20 percent in small playas. Dominant vegetation includes galleta, shadscale, Indian ricegrass, Greenes low rabbitbrush, cheatgrass, winterfat, and halogeton. Elevation ranges from 1,555 to 1,575 m with precipitation averaging about 15 cm.

Lynndyl Sandy Loam (LdB)

The Lynndyl series consists of very deep, well drained soils with moderate permeability and slow surface runoff. They occur on alluvial fans and on short colluvial slopes. Soils are developing in mixed alluvium and colluvium primarily from igneous parent materials. Elevation ranges from 1,676 to 1,920 m with slope gradients ranging from 2 to 10 percent. Precipitation averages 17 to 20 cm.

Dominant plants are Greenes low rabbitbrush, black sagebrush, Nevada ephedra, shadscale, Indian ricegrass, and some littleleaf horsebrush (*Tetradymia glabrata*). The effective rooting depth is usually 28 to 60 cm.

Lynndyl soils are associated with Dera, Hiko Springs, and Pintwater soils.

Taxonomic Class—Sandy, mixed, mesic Typic Haplocalcids.

Typical Profile—A representative profile of Lynndyl sandy loam, 2 to 10 percent slopes, described at a point 762 m south and 610 m west of the northeast corner of sec. 26, T. 25S., R. 18W. follows:

A—0 to 8 cm; pale brown (10YR 6/3) sandy loam, dark brown (10YR 4/3) moist; weak thin platy structure; slightly hard, very friable, nonsticky, nonplastic; few fine and medium roots; many fine vesicular pores; 10 to 15 percent gravel; slightly effervescent; moderately alkaline (pH 8.4); clear wavy boundary (8 to 13 cm thick).

Bw—8 to 35 cm; pale brown (10YR 6/3) sandy loam, dark brown (10YR 4/3) moist; weak fine subangular blocky structure; slightly hard, very friable, nonsticky,

nonplastic; few fine and medium roots; 15 percent gravel; moderately calcareous; moderately alkaline (pH 8.4); gradual wavy boundary (0 to 28 cm thick).

Ck—35 to 63 cm; very pale brown (10YR 7/3) gravelly sandy loam, brown (10YR 5/3) moist; massive; hard, very friable, slightly sticky, slightly plastic; few fine and medium roots; 30 percent gravel; strongly effervescent; very strongly alkaline (pH 9.2); gradual irregular boundary (23 to 38 cm thick).

C1—63 to 105 cm; brown (10YR 5/3) gravelly sand, dark brown (10YR 4/3) moist; single grained; loose; 30 percent gravel; slightly effervescent; moderately alkaline (pH 8.4); gradual wavy boundary (15 to 40 cm thick).

C2—105 to 150 cm; brown (10YR 5/3) very gravelly sand, dark brown (10YR 4/3) moist; single grained; loose; 55 percent gravel; slightly effervescent; moderately alkaline (pH 8.4).

Rock fragments range from 20 to 35 percent in the control section. The upper boundary of the calcic horizon begins at a depth of 23 to 40 cm. Calcium carbonate equivalent averages 18 to 22 percent in the calcic horizon and 8 to 14 percent in the fine earth material for other horizons.

Small areas of Dera gravelly sandy loam, Hiko Springs gravelly sandy loam, and Pintwater gravelly sandy loam are included in mapping. These inclusions represent 10 percent of the unit.

Overland Gravelly Loam (OrE)

The Overland series consists of moderately deep, well drained soils with moderate permeability and medium surface runoff. These soils occur on moderately steep mountain slopes. Soils are developing in mixed alluvium, colluvium, and residuum from dolomite and limestone. Elevations range from 2,010 to 2,435 m with slope gradients ranging from 5 to 35 percent. Precipitation varies from 22 to 30 cm.

Dominant plants are singleleaf pinyon, Utah juniper, littleleaf mountain-mahogany (*Cercocarpus intricatus*), blue grama, black sagebrush, shadscale, needle-and-thread (*Stipa comata*), and broom snakeweed. The effective rooting depth is 50 to 100 cm.

Overland soils are associated with Yaki, Ansping, and Dera soils.

Taxonomic Class—Loamy-skeletal, carbonatic, frigid Xeric Haplocalcids.

Typical Pedon—A representative profile of Overland gravelly loam, 5 to 35 percent slopes, described at a point 91 m north and 549 m east of the southwest corner of sec. 11, T. 24S., R. 17W. follows:

A—0 to 13 cm; light brownish gray (10YR 6/2) gravelly loam, dark brown (10YR 4/3) moist; weak thin platy structure; slightly hard, firm, sticky, plastic; few fine and medium roots; few fine pores; 40 percent gravel and cobble; strongly effervescent; strongly alkaline (pH 8.6); gradual wavy boundary (8 to 15 cm thick).

Bw—13 to 33 cm; pale brown (10YR 6/3) gravelly loam, brown (10YR 5/3) moist; weak medium subangular blocky structure; slightly hard, firm, sticky, plastic; few fine and medium roots; 40 percent gravel and cobble; strongly effervescent; strongly alkaline (pH 8.8); clear wavy boundary (20 to 25 cm thick).

Ck—33 to 53 cm; very pale brown (10YR 7/3) very gravelly silt loam, brown (10YR 5/3) moist; weak, medium subangular blocky structure; slightly hard, firm, sticky, plastic; 55 percent gravel and cobble; strongly effervescent; strongly alkaline (pH 8.8); gradual wavy boundary (20 to 33 cm thick).

C—53 to 75 cm; very pale brown (10YR 7/3) very gravelly fine sandy loam, dark yellowish brown (10YR 4/4) moist; massive; soft, friable, slightly sticky, slightly plastic; few fine and medium roots; 60 percent gravel; violently effervescent; moderately alkaline (pH 8.4); clear wavy boundary.

R—75 cm; fractured dolomite.

Rock fragments average more than 35 percent in the control section. The upper boundary of the calcic horizon begins at a depth of 28 to 43 cm. The calcium carbonate equivalent exceeds 40 percent when considering the whole soil less than 20 mm diameter. Rock fragments have 65 to 75 percent calcium carbonate equivalent with fine earth materials averaging about 30 percent. Small areas of rock outcrop, alluvial land, and Yaki soils are included in mapping. These inclusions represent 15 percent of the unit.

Penoyer Very Fine Sandy Loam (PeA)

The Penoyer series consists of very deep, well drained soils with moderately slow permeability and slow surface runoff. These soils occur in the valley bottoms. Soils are developing in mixed alluvium from dolomite, quartzite and igneous materials. Elevation ranges from 1,554 to 1,615 m with slope gradients ranging from 0 to 3 percent. Precipitation averages about 15 cm. Dominant plant species are winterfat and halogeton with some shadscale. The effective rooting depth ranges from 23 to 88 cm.

Penoyer soils are commonly associated with Tipperary, Juva, and Hiko Springs soils.

Taxonomic Class—Coarse-silty, mixed, calcareous, mesic Typic Torriorthents.

Typical Pedon—A representative profile of Penoyer very fine sandy loam, 0 to 3 percent slopes, described

at a point 150 m east and 600 m south of the northwest corner of sec. 13, T. 25S., R. 17W. follows:

A—0 to 8 cm; pale brown (10YR 6/3) very fine sandy loam, dark brown (10YR 4/3) moist; weak medium platy structure; soft, firm, slightly sticky, slightly plastic; few fine and medium roots; many fine vesicular pores; strongly effervescent; strongly alkaline (pH 8.6); gradual wavy boundary (8 to 15 cm thick).

C1—8 to 35 cm; very pale brown (10YR 7/3) very fine sandy loam, dark brown (10YR 4/3) moist; weak medium platy structure; soft, firm, slightly sticky, slightly plastic; few fine and medium roots; strongly effervescent; strongly alkaline (pH 8.9); gradual wavy boundary (20 to 35 cm thick).

C2—35 to 55 cm; very pale brown (10YR 7/3) very fine sandy loam, brown (10YR 5/3) moist; weak medium subangular blocky structure; soft, firm, slightly sticky, slightly plastic; few fine and medium roots; strongly effervescent; strongly alkaline (pH 8.7); diffuse wavy boundary (20 to 43 cm thick).

C3—55 to 95 cm; very pale brown (10YR 7/3) very fine sandy loam, brown (10YR 5/3) moist; massive; soft, firm, slightly sticky, slightly plastic; strongly effervescent; strongly alkaline (pH 8.8); gradual wavy boundary (30 to 55 cm thick).

C4—95 to 125 cm; pale brown (10YR 6/3) very fine sandy loam, brown (10YR 5/3) moist; massive; soft, firm slightly sticky, slightly plastic; strongly effervescent; strongly alkaline (pH 8.9); gradual wavy boundary (30 to 38 cm thick).

C5—125 to 150 cm; pale brown (10YR 6/3) very fine sandy loam, brown (10YR 5/3) moist; massive; soft, firm, slightly sticky, slightly plastic; strongly effervescent; strongly alkaline (pH 8.9).

Rock fragments are less than 5 percent in the control section.

Calcium carbonate equivalent averages 20 to 25 percent throughout the profile.

Small areas of Juva sandy loam and Tipperary loamy sand are included. These inclusions represent 5 percent of the unit.

Pintwater Gravelly Sandy Loam (PtD)

The Pintwater series consists of shallow, well drained soils with moderate permeability and medium surface runoff. These soils occur on small rolling hills and steep mountain slopes. Soils are developing in residuum from andesite, latite, and trachyte. Elevation ranges from 1,798 to 2,012 m with slope gradients ranging from 3 to 35 percent. Precipitation is 17 to 23 cm.

Dominant plants are black sagebrush, Greenes low rabbitbrush, Nevada ephedra, Indian ricegrass, littleleaf horsebrush, and shadscale. The effective rooting depth is 25 to 38 cm.

Pintwater soils are commonly associated with Lynndyl, Dera, Hiko Springs, and Sardo soils.

Taxonomic Class—Loamy-skeletal, mixed, calcareous, mesic Lithic Torriorthents.

Typical Pedon—A representative profile of Pintwater gravelly loam, 3 to 35 percent slopes, described at a point 152 m east and 185 m south of the northwest corner of sec. 29, T. 24S., R. 17W. follows:

A—0 to 5 cm; pale brown (10YR 6/3) gravelly sandy loam, dark brown (10YR 4/3) moist; moderate medium platy structure; soft, friable, slightly sticky, slightly plastic; few fine roots; many fine vesicular pores; 25 percent gravel; slightly effervescent; strongly alkaline (pH 8.7); clear smooth boundary (5 to 15 cm thick).

Bw—5 to 15 cm; brown (10YR 5/3) gravelly sandy loam, dark brown (10YR 4/3) moist; weak fine subangular blocky structure; soft, friable, slightly sticky, slightly plastic; few fine roots; 35 percent gravel; strongly effervescent; strongly alkaline (pH 8.6); clear wavy boundary (0 to 15 cm thick).

Ck—15 to 28 cm; brown (10YR 5/3) very gravelly sandy loam, brown (10YR 4/3) moist; massive; soft, friable, slightly sticky, slightly plastic; 60 percent gravel; strongly effervescent; strongly alkaline (pH 8.6); gradual wavy boundary (0 to 15 cm thick).

R—28 cm; fractured igneous rock.

Rock fragments average more than 35 percent above bedrock. The Bw horizon is too thin to qualify as a cambic horizon. The Ck is too thin to qualify as a calcic horizon or has less than 15 percent calcium carbonate equivalent.

Small areas of igneous rock outcrop, Alluvial land, Lynndyl sandy loam, and Dera gravelly sandy loam are included. These inclusions represent 15 percent of the unit.

Playa (P1)

The Playa miscellaneous land type occurs northeast of headquarters in an old lake bed. The soil material is very deep, fine textured, and very slowly permeable. Slopes are less than 1 percent. There is no natural drainage outlet and water stands for lengthy periods of time during some years. Other years, the area is dry. Large cracks form hexagonal patterns on the soil surface. Elevation is near 1,555 m with precipitation averaging near 15 cm.

Most areas are barren. However, in some spots scattered halogeton, greasewood (*Sarcobatus vermiculatus*), Bonneville saltbush (*Atriplex*

bonnevillensis), and gray molly (*Kochia americana*) are growing. Halogeton is a conspicuous part of the annual vegetation.

Rockland-Dolomite (R1)

This miscellaneous land type occurs on the steep mountain ranges extending from the southern border to the northern border. Dominant slopes are from 20 to 60 percent, but vertical cliffs are scattered throughout the areas. About 50 to 75 percent of the area is rock outcrop, slide rock, or shallow to moderately deep soils covered with a cobble and stone surface mantle. These soils are in the Yaki and Overland series. Dolomite is the dominant rock type with small areas of limestone. Vegetation is dominated by singleleaf pinyon, Utah juniper, littleleaf mountain-mahogany, Nevada greasebush (*Forsellesia nevadensis*), and a few grasses and forbs. Elevation ranges from 1,707 to 2,578 m with precipitation ranging from 17 to 30 cm.

Because of the steepness of the slopes and the lack of a dense vegetative cover, runoff is rapid and sediment production is high.

Rockland—Igneous (R2)

This miscellaneous land type occurs on rolling hills and steep mountain ranges. Dominant slopes are from 10 to 40 percent, but vertical cliffs are present in some areas. About 25 to 70 percent of the area is rock outcrop or shallow soils covered with a cobble and stone surface mantle. The major soils are in the Pintwater series. Extrusive igneous rocks, primarily andesite, latite, and trachyte are present. Vegetation is dominated by black sagebrush, Nevada ephedra, littleleaf horsebrush, Greenes low rabbitbrush, and some Indian ricegrass. Elevation ranges from 1,768 to 2,212 m with precipitation ranging from 17 to 35 cm.

Because of the steepness of the slopes and the lack of a dense vegetative cover, runoff is rapid and sediment production is high.

Rockland—Quartzite (R3)

This miscellaneous land type occurs on small isolated hills and on mountain ranges. Dominant slopes are from 20 to 60 percent, but vertical cliffs are scattered throughout the areas. About 25 to 75 percent of the area is rock outcrop, slide rock, or shallow to moderately deep soils covered with a cobble and stone surface mantle. The soils include the Yaki and Pintwater series. Quartzite is the dominant rock type with small areas of dolomite. Vegetation is mainly singleleaf pinyon, Utah juniper, littleleaf mountain-mahogany, and shadscale. Elevation ranges from 1,707 to 2,438 m with mean precipitation ranging from 17 to 30 cm.

Because of the steepness of the slopes and the lack of a dense vegetative cover, runoff is rapid and sediment production is high.

Sagers Silt Loam (SaA)

Sagers soils have very deep, well drained profiles with slow permeability and moderate surface runoff. These soils occur in the valley bottoms adjacent to the playa northeast of headquarters where some new deposition is common after major storms. Soils are developing in mixed alluvium from dolomite, quartzite and igneous materials. Elevation ranges from 1,554 to 1,585 m with slope gradients ranging from 0 to 2 percent. Precipitation averages about 15 cm.

Vegetation includes small patches of greasewood and Bonneville saltbush. Halogeton invades these sites on wet years. Effective rooting depth is less than 50 cm even though soils are very deep.

Sagers soils are commonly associated with Uffens sandy loam, Penoyer very fine sandy loam and playa areas.

Taxonomic Class—Fine-silty, mixed, calcareous, mesic Typic Torriorthents.

Typical Pedon—A representative profile of Sagers silt loam, 0 to 2 percent slopes, described at a point 183 m east and 427 m south of the southwest corner of sec. 23, T. 25S., R. 17W. follows:

A—0 to 15 cm; pale brown (10YR 6/3) silt loam, dark brown (10YR 4/3) moist; weak medium platy structure; soft, firm, sticky, plastic; few fine roots; many fine vesicular pores; strongly effervescent; strongly alkaline (pH 8.6); clear wavy boundary.

C1—15 to 35 cm; pale brown (10YR 6/3) silt loam, dark brown (10YR 4/3) moist; weak thin platy structure; soft, firm, sticky, plastic; few fine roots; few fine vesicular pores; strongly effervescent; strongly alkaline (pH 8.6); gradual wavy boundary.

C2—35 to 65 cm; pale brown (10YR 6/3) silt loam, dark brown (10YR 4/3) moist; massive; soft, firm, sticky, plastic; strongly effervescent; strongly alkaline (pH 8.6); diffuse wavy boundary.

C3—65 to 95 cm; pale brown (10YR 6/3) silt loam, dark brown (10YR 4/3) moist; massive; soft, firm, sticky, plastic; strongly effervescent; strongly alkaline (pH 8.6); diffuse wavy boundary.

C4—95 to 130 cm; pale brown (10YR 6/3) silt loam, dark brown (10YR 4/3) moist; massive; soft, firm sticky, plastic; strongly effervescent; strongly alkaline (pH 8.6); diffuse wavy boundary.

C5—130 to 150 cm; pale brown (10YR 6/3) silty clay loam, dark brown (10YR 4/3) moist; massive; soft,

firm, sticky, plastic; strongly effervescent; moderately alkaline (pH 8.4).

Rock fragments are less than 5 percent in the control section. Little variation was observed in soil characteristics with increasing depth. Calcium carbonate equivalent averages 25 percent throughout the profile.

Small areas of Uffens sandy loam, Penoyer very fine sandy loam, and some playa lands are included in mapping. The inclusions are less than 5 percent of the area.

Sardo Gravelly Sandy Loam (ScC)

The Sardo series consists of very deep, well drained soils with moderate permeability and medium surface runoff. These soils occur on long alluvial fans and on short colluvial slopes. Soils are developing in mixed alluvium from dolomite, quartzite, and igneous materials. Elevation ranges from 1,615 to 2,012 m with slope gradients ranging from 3 to 15 percent. Mean precipitation varies from 15 to 23 cm.

Vegetation is dominated by budsage, shadscale, winterfat, sand dropseed, cheatgrass, galleta, purple threeawn, blue grama, and Indian ricegrass. The effective rooting depth is 50 to 75 cm.

Sardo soils are commonly associated with Dera, Aysees, Hiko Springs, and Yaki soils.

Taxonomic Class—Loamy-skeletal, carbonatic, mesic Typic Haplocambids.

Typical Pedon—A representative profile of Sardo gravelly sandy loam, 3 to 15 percent slopes, described at a point 91 m north and 183 m west of the southeast corner of sec. 10, T. 25S., R. 17W. follows:

A—0 to 8 cm; light brownish gray (10YR 6/2) gravelly sandy loam, dark grayish brown (10YR 4/2) moist; weak medium platy structure; soft, friable, slightly sticky, slightly plastic; few fine and medium roots; many fine vesicular pores; 25 percent gravel; strongly effervescent; strongly alkaline (pH 8.6); gradual wavy boundary (8 to 15 cm thick).

Bw—8 to 33 cm; pale brown (10YR 6/3) gravelly sandy loam, dark brown (10YR 4/3) moist; weak medium subangular blocky structure; soft, friable, nonsticky, nonplastic; few fine and medium roots; few fine vesicular pores; 35 percent gravel; strongly effervescent; strongly alkaline (pH 8.8); gradual wavy boundary (18 to 33 cm thick).

Ck—33 to 43 cm; pale brown (10YR 6/3) gravelly sandy loam, dark brown (10YR 4/3) moist; weak medium subangular blocky structure; soft, friable, nonsticky, nonplastic; common fine roots; 35 percent gravel; strongly effervescent; strongly alkaline (pH 8.9); gradual wavy boundary (8 to 18 cm thick).

C1—43 to 63 cm; pale brown (10YR 6/3) gravelly sandy loam, dark brown (10YR 4/3) moist; massive; soft, friable, nonsticky, nonplastic; 40 percent gravel; strongly effervescent; strongly alkaline (pH 8.9); gradual wavy boundary (20 to 45 cm thick).

C2—63 to 150 cm; light yellowish brown (10YR 6/4) gravelly sandy loam, dark yellowish brown (10YR 4/4) moist; massive; soft, friable, nonsticky, nonplastic; 45 percent gravel; strongly effervescent; strongly alkaline (pH 8.6).

Rock fragments average more than 35 percent in the control section. Secondary carbonate accumulation begins at 25 to 38 cm, but is less than 15 cm thick and calcium carbonate equivalent is only 3 to 4 percent greater than in adjacent horizons. The calcium carbonate equivalent exceeds 40 percent when considering the whole soil less than 20 mm diameter. Rock fragments have 60 to 70 percent calcium carbonate equivalent with the fine earth materials averaging over 30 percent.

Small areas of Dera gravelly sandy loam, Hiko Springs gravelly sandy loam, Tipperary loamy sand, and alluvial land are included. These inclusions represent 10 to 15 percent of the unit.

Tipperary Loamy Sand (TcA)

The Tipperary series consists of very deep, somewhat excessively drained soils with rapid permeability and slow surface runoff. These soils occur in the valley bottoms near the large playa and along many drainageways. Soils are developing in alluvium and colluvium from dolomite, quartzite, and igneous parent materials. Some windblown sand is also present. Elevations range from 1,554 to 1,675 m with slopes ranging from 0 to 5 percent. Precipitation ranges from 15 to 18 cm.

Vegetation is dominated by Indian ricegrass and Greenes low rabbitbrush with lesser amounts of shadscale, winterfat, sand dropseed, budsage, and cheatgrass. Halogeton and Russian thistle occupy some areas in wet years. The effective rooting depth is usually 38 to 75 cm.

Tipperary soils are associated with Aysees gravelly sandy loam, Juva sandy loam, and Uffens sandy loam.

Taxonomic Class—Mixed, mesic Typic Torripsamments.

Typical Pedon—A representative profile of Tipperary loamy sand, 0 to 3 percent slopes, described at a point 762 m north and 610 m west of the southeast corner of sec. 12, T. 25S., R. 17W. follows:

A—0 to 15 cm; light brownish gray (10YR 6/2) sand, dark grayish brown (10YR 4/2) moist; weak fine platy structure; loose; few fine and medium roots; slightly

effervescent; moderately alkaline (pH 8.2); gradual wavy boundary (8 to 15 cm thick).

C1—8 to 45 cm; light brownish gray (10YR 6/2) sand, dark grayish brown (10YR 4/2) moist; single grained; loose; few fine and medium roots; slightly effervescent; moderately alkaline (pH 8.2); clear wavy boundary (18 to 65 cm thick).

Ck—45 to 60 cm; light brownish gray (10YR 6/2) loamy sand, dark grayish brown (10YR 4/2) moist; massive; soft, very friable, nonsticky, nonplastic; few fine and medium roots; slightly effervescent; moderately alkaline (pH 8.4); clear wavy irregular boundary (15 to 40 cm thick).

C2—60 to 100 cm; light brownish gray (10YR 6/2) loamy sand, dark grayish brown (10YR 4/2) moist; single grained; loose; 30 percent gravel; slightly effervescent; moderately alkaline (pH 8.4); gradual wavy boundary (15 to 40 cm thick).

C3—100 to 150 cm; light brownish gray (10YR 6/2) sand, dark grayish brown (10YR 4/2) moist; single grained; loose; slightly effervescent; strongly alkaline (pH 8.6).

The particle size control section averages more than 75 percent sand and less than 35 percent rock fragments. Textures are loamy sand, sandy loam, and sand. Calcium carbonate equivalent averages 10 to 20 percent with secondary carbonate accumulations in the Ck horizon failing to meet all requirements for a calcic horizon.

Juva, Aysees, and Uffens soils together with some small playas and alluvial lands represent 8 to 10 percent of the unit as inclusions.

Uffens Sandy Loam (UaB)

The Uffens sandy loam consists of very deep, well drained soils with moderately slow permeability and medium surface runoff. These soils occur in valley bottoms near the large playa northeast of headquarters. Soils are developing in mixed alluvium from dolomite, quartzite, and igneous materials. Some windblown sand collects around the plants. Elevation ranges from 1,554 to 1,575 m with slope gradients ranging from 1 to 5 percent. Precipitation averages about 15 cm.

Dominant plants are gray molly (which is a good indicator for this soil), shadscale, galleta, and Indian ricegrass. Russian thistle and halogeton are heavy producers during moist years. The effective rooting depth is 25 to 75 cm.

Uffens soils are commonly associated with Tipperary loamy sand, Juva loamy sand, Sagers silt loam, and Hiko Springs gravelly sandy loam.

Taxonomic Class—Fine-loamy, mixed, mesic Typic Natrargid.

Typical Pedon—A representative profile of Uffens sandy loam, 1 to 5 percent slopes, described at a point 762 m west and 366 m south of the northeast corner of sec. 36, T. 25S., R. 17W. follows:

E1—0 to 5 cm; light gray (10YR 7/2) sandy loam, dark grayish brown (10YR 4/2) moist; moderate, thick platy structure; slightly hard, firm, nonsticky, nonplastic; few fine roots; many medium vesicular pores; slightly effervescent; strongly alkaline (pH 8.6); clear smooth boundary (5 to 13 cm thick).

E2—5 to 18 cm; light gray (10YR 7/2) sandy loam, dark grayish brown (10YR 4/2) moist; weak medium platy structure; slightly hard, firm, slightly sticky, slightly plastic; few fine roots; many fine vesicular pores; slightly effervescent; very strongly alkaline (pH 9.4); clear smooth boundary (0 to 13 cm thick).

Btn—18 to 43 cm; light gray (10YR 7/2) sandy clay loam, grayish brown (10YR 5/2) moist; moderate coarse prismatic structure; hard, firm, slightly sticky, slightly plastic; few fine roots; slightly effervescent; strongly alkaline (pH 8.6); gradual smooth boundary (18 to 48 cm thick).

Ck—43 to 60 cm; light brownish gray (10YR 6/2) sandy clay loam, grayish brown (2.5YR 5/2) moist; moderate medium platy structure; hard, firm, slightly sticky, slightly plastic; strongly effervescent; moderately alkaline (pH 8.4); gradual wavy boundary (0 to 35 cm thick).

C—60 to 100 cm; light yellowish brown (2.5YR 6/3) sandy clay loam, light olive brown (2.5YR 5/3) moist; weak medium prismatic structure; hard, firm, slightly sticky, slightly plastic; strongly effervescent; moderately alkaline (pH 8.4); clear irregular boundary (15 to 60 cm thick).

2C—100 to 150 cm; light gray (2.5YR 7/2) silty clay loam, light brownish gray (2.5YR 6/2) moist; strong medium angular blocky structure; extremely hard, very firm, sticky, plastic; strongly effervescent; strongly alkaline (pH 8.6).

Rock fragments average less than 15 percent in the control section. Stratification within the profile is common. Exchangeable sodium in the Btn horizon exceeds 20 percent.

Areas of Hiko Springs gravelly sandy loam, Juva sandy loam, and many small playas are included. These inclusions represent 10 to 15 percent of the unit.

Yaki Gravelly Loam (YaD)

The Yaki series consists of shallow, well drained soils with moderate permeability to bedrock and medium surface runoff. These soils occur on gently rolling hills and steep mountain slopes. Soils are developing in residuum and colluvium from dolomite and limestone. Elevations range from 1,707 to 2,103 m with slope gradients ranging from 3 to 40 percent. Mean precipitation varies from 17 to 25 cm.

Vegetation is dominated by shadscale, needle-and-thread, and blue grama, with lesser amounts of Indian ricegrass, sand dropseed, and black sagebrush. The effective rooting depth ranges from 25 to 50 cm.

Yaki soils are commonly associated with Dera, Pintwater, and Sardo soils.

Taxonomic Class—Loamy-skeletal, carbonatic, mesic Lithic Haplocalcids.

Typical Pedon—A representative profile of Yaki gravelly loam, 3 to 40 percent slopes, described at a point 31 m west and 305 m north of the southeast corner of sec. 1, T. 25S., R. 18W. follows:

A—0 to 5 cm; pale brown (10YR 6/3) gravelly loam, dark brown (10YR 4/3) moist; weak thin platy structure; soft, firm, slightly sticky, slightly plastic; few fine roots; 45 percent gravel; strongly effervescent; strongly alkaline (pH 8.5); clear wavy boundary (5 to 15 cm thick).

C—5 to 20 cm; pale brown (10YR 6/3) gravelly silt loam, dark brown (10YR 4/3) moist; weak medium subangular blocky structure; soft, firm, slightly sticky, plastic; few fine roots; 40 percent gravel; strongly effervescent; strongly alkaline (pH 8.5); gradual wavy boundary (0 to 18 cm thick).

Ck—20 to 35 cm; very pale brown (10YR 8/3) very gravelly silt loam, brown (10YR 5/3) moist; massive; soft, firm, sticky, plastic; few fine roots; 45 percent gravel; very strongly effervescent; strongly alkaline (pH 8.9); gradual wavy boundary (15 to 20 cm thick).

R—35 cm; fractured dolomite.

The depth to bedrock ranges from 25 to 50 cm with the whole soil averaging over 40 percent calcium carbonate equivalent. The calcic horizon has about 50 percent calcium carbonate equivalent and begins at a depth of 10 to 25 cm. Rock fragments in individual layers range from 25 to 80 percent, but average more than 35 percent in the control section.

Dera gravelly sandy loam and Overland gravelly loam together with rock outcrops and Alluvial land are included in mapping. These inclusions represent 15 to 20 percent of the unit.

Soil and Landscape Characteristics

To expedite interpretations, soil mapping units were grouped into clusters where a few dominant soil and landscape features have a controlling influence on the type and quantity of vegetation being produced. The five dominant soil groups are described below with letters that match those given in figure 1. Pertinent soil characteristics and landscape features are given that are followed in the next section by estimates on herbage production, where the focus is on dominant plant species that are affected by specific soil characteristics.

Xeric Uplands (A)

Soil characteristics are considered collectively for shallow, moderately deep, and deep, loamy-skeletal, carbonatic materials. The soil units are intermingled with steep rocklands which severely restrict land management and use.

Although carbonate contents are high in these soils, soluble salts have been leached from the surface horizons and are not restricting root growth and production to the extent observed on the dry lower elevation sites. Surface horizons have electrical conductivities (EC's) of less than 1 decisiemen/meter (dS/m) (previously millimhos/cm; 1 millimhos/cm = 1 decisiemen/m) to a depth of 50 cm. At a depth of 75 cm, EC's are near 3 dS/m. To put this in perspective, salinity effects on native vegetation are diminutive below 4 dS/m. Growth of sensitive plants is reduced with EC's between 4 and 8 dS/m. When EC's exceed 16 dS/m, only the most tolerant plants yield satisfactorily. Soluble salts in the lower horizons of soils located on the lowlands are a much greater problem in restricting root growth than on upland sites.

Shallow Soils and Low Rocky Hills (B)

Soils on the low hills located at the base of the taller mountains are less than 50 cm deep. Here, salts have been leached from the soil materials above bedrock, with EC's averaging less than 1 dS/m, but root growth is impeded by the shallow soils and high contents of rock fragments.

For the Yaki soils, carbonates exceed 40 percent for the fine materials as well as for rock fragments less than 20 mm in diameter, thus producing carbonatic mineralogy. For the Pintwater soils that develop in igneous materials, carbonate content is near 10 percent. Exchangeable sodium is near 5 percent for both soils.

Table 4—Herbage production by species on deep, loamy-skeletal, carbonatic soils at the Desert Experimental Range.

Grasses			Forbs			Shrubs		
Species[a]	*Kg/ha*	*Percent comp*	*Species*	*Kg/ha*	*Percent comp*	*Species*	*Kg/ha*	*Percent comp*
ARPU	2.2	0.90	LEMO	1.1	0.45	ARFR	1.1	0.45
BOGR	3.4	1.34	SAIB	1.1	.45	ARSP	4.5	1.79
BLKI	1.1	.45	SPGR	6.7	2.69	ATCA	1.1	.45
HIJA	34.7	13.90	Other	3.4	1.34	ATCO	80.6	32.29
ORHY	16.8	6.73				CELA	23.5	9.41
SPCR	29.1	11.66				CHSPP	3.4	1.35
Other	2.2	.87				CHGR	3.4	1.35
						EPNE	14.6	5.82
						PRFA	3.4	1.35
						GUSA	9.0	3.58
						Other	3.4	1.35
Subtotal	89.5	35.88		12.3	4.93		148.0	59.19
Grand total							249.8	100

[a]See table 6 for plant names.

Table 5—Herbage production on deep, coarse-loamy, sandy and silty soils at the Desert Experimental Range.

Grasses			Forbs			Shrubs		
Species[a]	*Kg/ha*	*Percent comp*	*Species*	*Kg/ha*	*Percent comp*	*Species*	*Kg/ha*	*Percent comp*
ARPU	1.1	0.43	LEMO	1.1	0.43	ARFR	4.5	1.72
BOGR	1.1	.43	SAIB	13.4	5.14	ARSP	2.2	.86
HIJA	12.3	4.71	SPGR	7.9	3.01	ATCA	2.2	.86
ORHY	10.1	3.86	Other	3.4	1.29	ATCO	84.0	32.19
SPCR	5.6	2.15				CELA	93.0	35.61
Other	6.7	2.58				CHSPP	1.1	.43
						CHGR	6.7	2.58
						EPNE	1.1	.43
						PRFA	1.1	.43
						GUSA	1.1	.43
						Other	1.1	.43
Subtotal	36.9	14.16		25.8	9.87		198.1	75.97
Grand Total							260.8	100

[a]See table 6 for plant names.

Deep, Loamy-Skeletal, Carbonatic Soils (C)

Soil characteristics are considered collectively for the deep, loamy-skeletal, carbonatic soils on the long alluvial fans.

Salts have been leached from approximately the surface 40 cm as indicated by EC's of less than 1 dS/m. Below a depth of 40 cm, EC's increase dramatically as values ranging from about 10 to 35 dS/m, with EC's being considerably higher on the Dera soils than on the Sardo soils. Root growth is impacted by these high salt conditions. As EC's rise, exchangeable sodium follows a similar pattern with percentages ranging from 10 to 35 percent in lower horizons.

Deep, Coarse-Loamy, Mixed Soils (D)

Soil characteristics are considered collectively for the deep, coarse-loamy, coarse silty, or sandy textured soils. These soils occur at the lower elevations on gently sloping landscapes along the southeastern border.

Salts have been leached from approximately the surface 40 cm as indicated by EC's of less than 1 dS/m. Below a depth of 40 to 50 cm, EC's range from 2 to 30 dS/m with most in the 5 to 15 dS/m range. Root growth is impeded below 50 to 60 cm on many of these soils.

Table 6—Plant names and symbols for production estimates in tables 4 and 5.

Symbol	Common name	Scientific name
Grasses		
ARPU	Purple threeawn	*Aristida purpurea*
BLKI	King desertgrass	*Blepharidacne kingii*
BOGR	Blue grama	*Bouteloua gracilis*
HIJA	Galleta	*Hilaria jamesii*
SPCR	Sand dropseed	*Sporobolus cryptandrus*
ORHY	Indian ricegrass	*Oryzopsis hymenoides*
Forbs		
LEMO	Mountain pepperplant	*Lepidium montanum*
SAIB	Russian-thistle	*Salsola iberica*
SPGR	Gooseberryleaf globemallow	*Sphaeralcea grossulariifolia*
Shrubs		
ARFR	Fringed sagebrush	*Artemisia frigida*
ARSP	Budsage	*Artemisia spinescens*
ATCA	Fourwing saltbush	*Atriplex canescens*
ATCO	Shadscale	*Atriplex confertifolia*
CELA	Winterfat	*Ceratoides lanata*
CHSPP	Rabbitbrush species	*Chrysothamnus* spp.
CHGR	Viscid rabbitbrush	*Chrysothamnus greenei*
EPNE	Nevada ephedra	*Ephedra nevadensis*
GUSA	Broom snakeweed	*Gutierrezia sarothrae*
PRFA	Desert almond	*Prunus fasciculata*

Carbonate content ranges from 10 to 25 percent with some calcic horizons reaching 35 percent. None of these soils are classified as having carbonatic mineralogy. Exchangeable sodium is near 5 percent in the surface 38 cm with percentages reaching 15 to 40 percent in lower horizons.

Pine Valley Hardpan (E)

This mapping unit includes the Pine Valley hardpan and the very deep silty and fine-loamy soils along the northern and southern edges of the hardpan. Elevations are near 1,555 m with slopes less than 1 percent. Annual precipitation is about 15 cm. The hardpan is flooded when thunderstorms produce runoff from the surrounding hills.

Soils along the northern and southern edges of the hardpan are fine-silty and fine-loamy materials. Salts have been partially leached from the surface 40 cm as indicated by a relatively low EC's measured at less than 1.0 dS/m above 15 cm and less than 10 dS/m between 15 and 40 cm, but below 40 cm, EC's are excessive, being near 28 dS/m.

Carbonate content is near 25 percent in the top 150 cm. Exchangeable sodium is 15 to 23 percent in the lower horizons.

Herbage Production

Tables 4 and 5 present annual herbage production data for the deep, loamy-skeletal, carbonatic (pastures 1 to 6) and deep, coarse-loamy, mixed soils (pastures 15, 17 to 20) by species and growth form as it was sampled during the study period (1938 through 1957). Symbols are identified to species using the key in table 6. Herbage production estimates for all other soils groups are derived from precipitation data using the equations previously described. We emphasize that annual variations in precipitation cause large production deviations from the mean (fig. 3).

Xeric Uplands (A)

Moisture levels are higher in the xeric uplands than all other soil groups. Mean annual precipitation ranges from 23 to 30 cm per year. Herbage production estimates range from 260 to 315 kg per ha for the shallow soils, 315 to 435 kg per ha for the moderately deep soils, and about 485 kg per ha for the deep soils which only occur at one site in the 28 to 30 cm precipitation zone. Much of the production on these sites is attributed to singleleaf pinyon and Utah juniper that suppress understory production.

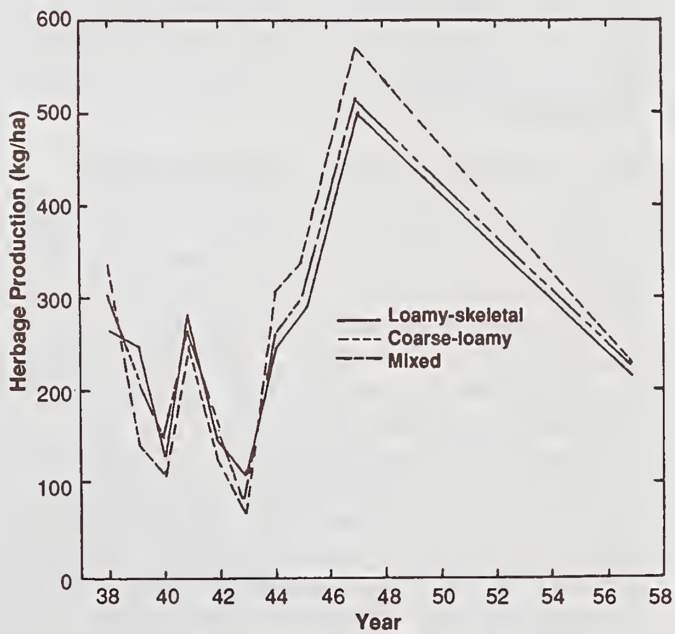


Figure 3—Herbage production estimates on three soil groups.

Dominant plant species include black sagebrush, shadscale, dwarf mountain mahogany, singleleaf pinyon, Utah juniper, bullgrass, and blue grama.

Shallow Soils and Low Rocky Hills (B)

Vegetation is dominated by black sagebrush, shadscale, Indian ricegrass, needle-and-thread grass, Nevada greasebush, and blue grama with a sparse singleleaf pinyon and Utah juniper overstory on the northern hills. Precipitation ranges from 18 to 25 cm. Estimated average annual herbage production is 200 to 286 kg per ha.

Deep, Loamy-Skeletal, Carbonatic Soils (C)

Mean annual herbage production for the deep, loamy-skeletal, carbonatic soils was 249.8 kg per ha (table 4). Dominant shrubs included shadscale, winterfat, and Nevada ephedra which together accounted for 48 percent of the total production. Dominant perennial grasses included galleta, sand dropseed, and Indian ricegrass that represented 32 percent of total production. The only prominent forb was gooseberryleaf globemallow that provided 3 percent of production. Together, the three grasses, three shrubs, and one forb represent 83 percent of the herbage production, showing the importance of a relatively few species.

Based on the precipitation versus production equation, mean annual herbage production should be 250 kg per ha and, using the statistical "z distribution", we estimate that production could exceed 385 kg per ha (mean value plus 1.28 times the standard deviation) or be less than 98 kg per ha 10 percent of the time. The actual range in production for the 10 years of record was 104 to 499 kg per ha that represents 42 to 200 percent of the mean.

Deep, Coarse-Loamy, Mixed Soils (D)

Mean annual herbage production for the deep, coarse-loamy, mixed soils was 260.8 kg per ha (table 5). Dominant shrubs were shadscale, winterfat, and Greenes low rabbitbrush that collectively accounted for 68 percent of total production. Dominant perennial grasses included galleta, Indian ricegrass, and sand dropseed that represented 11 percent of total production. Russian thistle produced large quantities of biomass some years and very little in others. Gooseberryleaf globemallow is common most years. Together, the three grasses, two shrubs, and two forbs represented 87 percent of the herbage production (table 4), again showing the importance of a relatively few species.

Based on the precipitation versus production equation, mean annual herbage production should be 260 kg per ha and, using the statistical "z distribution", we estimated herbage production could exceed 438 kg per ha or be less than 50 kg per ha 10 percent of the time. The actual range in production for the 10 years of record was 66 to 576 kg per ha which represents 25 to 221 percent of the mean.

Pine Valley Hardpan (E)

Vegetation is sparse on the Pine Valley hardpan with some halogeton, Bonneville saltbush, and greasewood being present. The fine-loamy soils along the edges of the hardpan produce abundant stands of gray molly. Because of the patchiness of vegetation on a generally barren landscape, use of any production equation based on precipitation would be inappropriate.

Discussion

Major differences occur in the type and quantity of vegetation being produced on different soil groups. Soil properties having an influence on plant growth include the carbonate content, rock fragment content, soil depth, soil texture, and salt content in the subsoil. Precipitation is the major climatic factor controlling production. Total herbage production increased proportional to increases in precipitation at a rate of approximately 21 kg per ha for each 1.0 cm increase in precipitation.

Herbage production estimates over time on loamy-skeletal and coarse-loamy soil groups together with estimates where both soil groups exist together (pastures 7 to 14 and 16) are shown in figure 3. There is little difference in total production among sites in a single year, however, differences are monumental between wet and dry years and between sites for a single species. For example, figure 4 shows differences in the yield of galleta on loamy-skeletal, carbonatic soils as compared to yield on coarse-loamy soils. For Nevada ephedra, loamy-skeletal soils again produce higher yields than coarse-loamy soils (fig. 5). The trend is reversed for winterfat (fig. 6). The higher soils-related yields encountered by these species are due primarily to higher plant or shoot densities and not to greater single plant productivity on any particular soil. Interestingly, production for shadscale, the most broadly adapted shrub species, is similar for both soil groups (fig. 7).

Plant community composition continues to change at the Desert Experimental Range in response to changes in climatic patterns, grazing treatments (including no grazing), and the introduction of alien annuals. In general, communities grazed during winter by sheep at moderate to heavy intensities developed increased dominance by perennial grasses and decreased importance of shrubs, than do nongrazed or lightly grazed communities (Kitchen and Hall 1996). Spring-grazed pastures see an even greater reduction in shrubs (shadscale excluded) coupled with an increase in warm

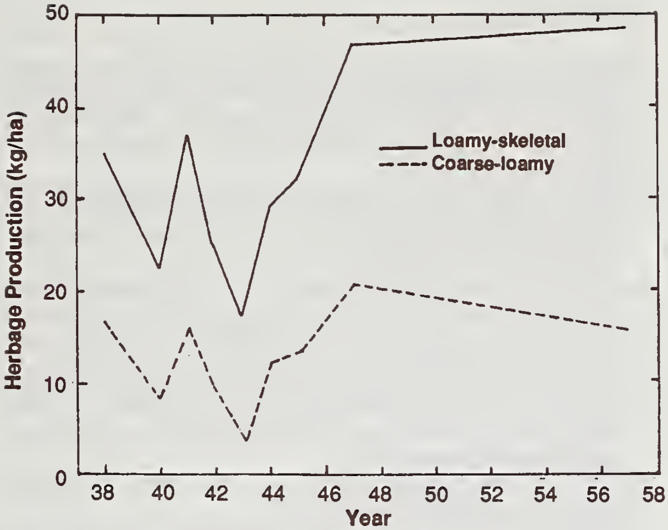


Figure 4—Galleta production on two soil groups.

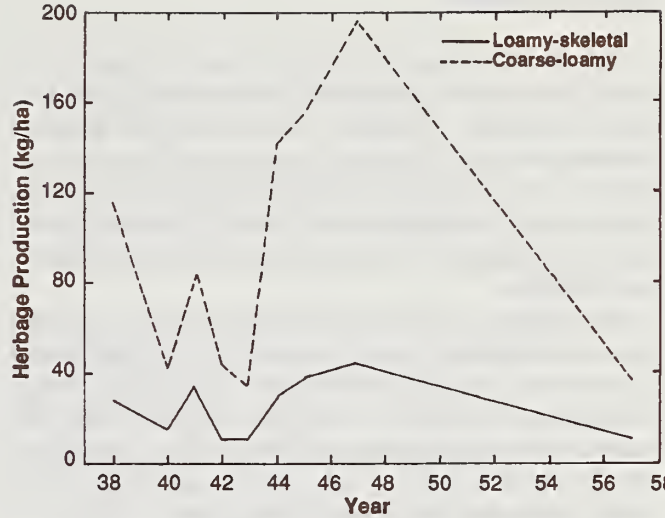


Figure 6—Winterfat production on two soil groups.

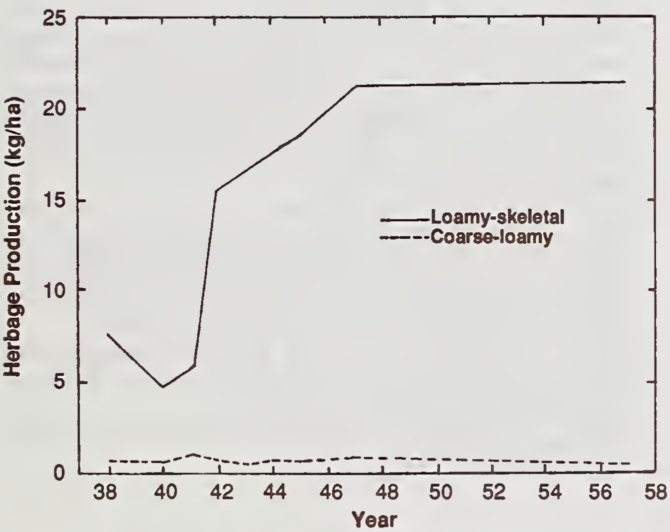


Figure 5—Nevada ephedra production on two soil groups.

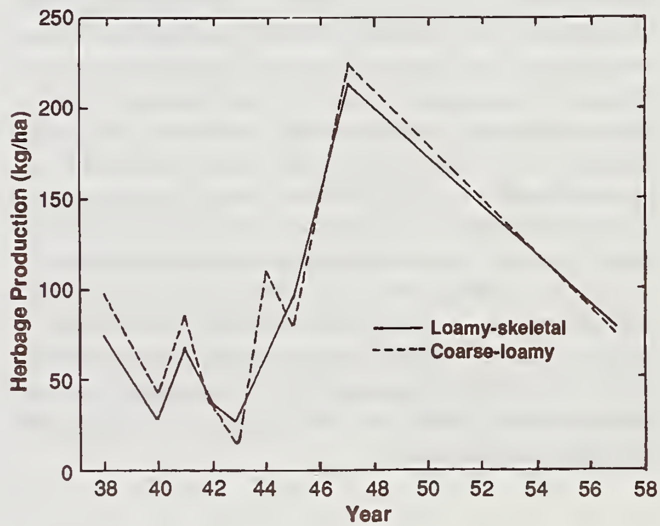


Figure 7—Shadscale production on two soil groups.

season perennials and introduced annuals. Because production is primarily limited by precipitation, we might expect mean production on a site to be similar after a change in community composition. However, in any given year, herbage production from distinct species assemblages found on similar soils might differ considerably due to the differential abilities of species to effectively use soil moisture in any given season. For example, summer storms effect quite different responses from communities dominated by cool-season versus warm-season species. In addition, production from annuals-dominated communities is more variable than from perennial communities. Halogeton, cheatgrass, and Russian thistle have gained considerable importance at the Desert Experimental Range and threaten the stability of perennial-dominated communities on some soil types (Harper and others 1996; Kitchen and Hall 1996). This is most evident on soils without rock pavements on the surface and where soil deposition and wind erosion continue to bring about change.

Conclusions

Long-term production studies made it possible to establish general production characteristics for specific soil groups. However, because specific grazing treatments were imposed on pastures having both similar and dissimilar soils present, there is some confounding of results that makes it impossible to clearly distinguish between soil and grazing treatment effects.

Soil mapping units and accompanying descriptions provide a reference point for designing new studies and a framework for interpreting previous studies. Broad soil groups establish a base for understanding the ecosystems present because soil depth, slope steepness, rock fragment contents, and precipitation patterns are neatly cataloged into rather homogeneous units.

Although individual soils are easily separated by closely following the National soil classification system, many differences are insignificant when developing soil interpretations for a desert environment. For example, the Aysees, Lynndyl, and Tipperary soils are all sandy, but have different classifications. Minor changes in rock fragment content, horizon stratification, and secondary carbonate enrichment lead to unique soil types, but these differences may be insignificant in a dry environment. Also, the Sardo and Dera soils differ only slightly in the depth and concentration of secondary carbonate accumulation resulting in two soil series with similar interpretations.

A major contribution from this study is the establishment of production estimates for a broad range of soil and climatic conditions in a rather harsh environment. These estimates provide information that can be turned into guidelines for the use and management of desert rangelands.

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Soils were mapped on the 22,533 ha Desert Experimental Range, Utah, to determine the kind, extent, and distribution of major soils and soil groups, the type of vegetation associated with each soil group, and the correlation between herbage production and soil groups. The results indicated that Desert Experimental Range soils are primarily Haplocalcids, Torriothents, and Torrifluvents. They occur within the Temperate Desert and Temperate Steppe climatic types. Annual herbage production averages 250 kg per ha per year. High production years yield twice the average, often with many annual herbs, while low production years yield less than half the average. Species composition differs greatly on dissimilar soils and over time, but total production is similar for Haplocalcids, Torriothents, and Torrifluvents.

Keywords: Aridisols, Entisols, Great Basin, herbage production, soil surveys, winter range

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The Intermountain Research Station provides scientific knowledge and technology to improve management, protection, and use of the forests and rangelands of the Intermountain West. Research is designed to meet the needs of National Forest managers, Federal and State agencies, industry, academic institutions, public and private organizations, and individuals. Results of research are made available through publications, symposia, workshops, training sessions, and personal contacts.

The Intermountain Research Station territory includes Montana, Idaho, Utah, Nevada, and western Wyoming. Eighty-five percent of the lands in the Station area, about 231 million acres, are classified as forest or rangeland. They include grasslands, deserts, shrublands, alpine areas, and forests. They provide fiber for forest industries, minerals and fossil fuels for energy and industrial development, water for domestic and industrial consumption, forage for livestock and wildlife, and recreation opportunities for millions of visitors.

Several Station units conduct research in additional western States, or have missions that are national or international in scope.

Station laboratories are located in:

Boise, Idaho

Bozeman, Montana (in cooperation with Montana State University)

Logan, Utah (in cooperation with Utah State University)

Missoula, Montana (in cooperation with the University of Montana)

Moscow, Idaho (in cooperation with the University of Idaho)

Ogden, Utah

Provo, Utah (in cooperation with Brigham Young University)

Reno, Nevada (in cooperation with the University of Nevada)